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## (54) Fuel injection pump for internal combustion engines

(57) Fuel injection pump for internal combustion engines having an enlarged passage opening 16 to improve the dissipation of kinetic energy of fuel both emerging from a relief hole 18 and flowing to a transverse duct 6 and thus reduce cavitation and metal erosion. The pump having a reciprocating pump piston (4) which is guided in a cylinder bush (2), having a control slide (5) which is axially displaceable on the pump piston (4) within a lateral recess of the cylinder bush (2), the control slide (5) being moveable by an adjustment shaft (7) located in the transverse duct (6) in the pump housing (1) located transversely to the cylinder axis. The transverse duct (6) intersects a bore (3) in the housing to form a suction space (11) with the formation of a passage opening (16) for a lever (8) of the control slide (5) and additionally serves to remove fuel from the suction space (11). This passage opening (16) is formed in a trough shape by a machining operation carried out from the housing hole (3) and the control slide (5) is shaped correspondingly.

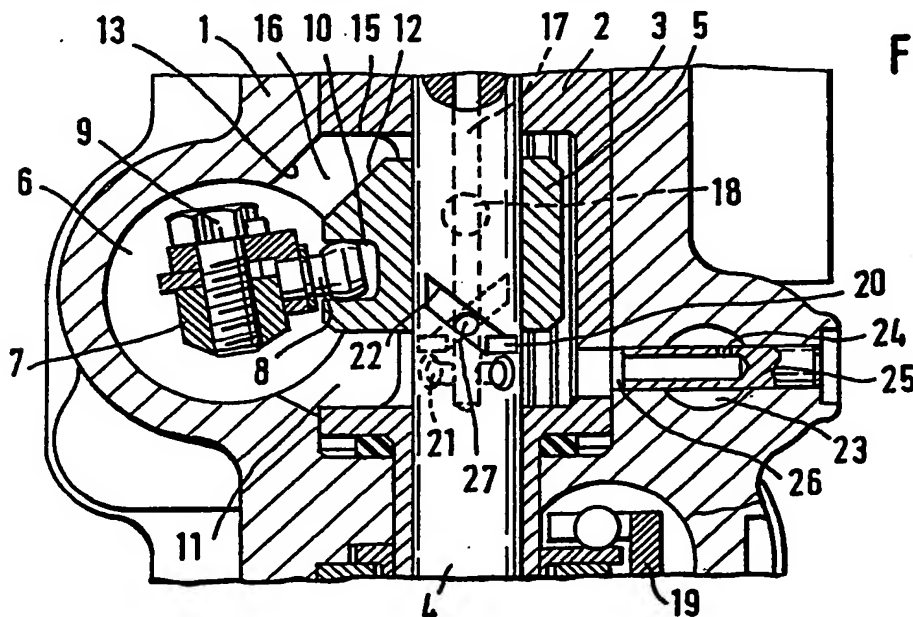


FIG. 1

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Fuel injection pump for internal combustion engines

## State of the art

The invention is based on a fuel injection pump for internal combustion engines of the generic type of Claim 1. Such a fuel injection pump is already known from US-A-47 37 086. In such slide-controlled fuel injection pumps, the injection quantity and/or the beginning of injection is determined by the axial position of the control slide. The adjustment of several such control slides is undertaken, in known manner, in an in-line pump arrangement by means of a common adjustment shaft on which is located a transmission element (lever) for each pump element. This shaft is located in a duct extending transversely to the pump axis and is rotatably supported at the two housing-side ends of the duct. So that the transmission element on the adjustment shaft can engage in a groove of the control slide, a passage opening is necessary on each cylinder from the transverse duct to the accommodation hole of the pump element, consisting of pump piston and pump cylinder. This opening is simultaneously also used as the fuel conduit between the individual pump elements and the transverse duct, which therefore acts as the return collecting duct. The beginning of delivery is controlled by the closing of the filling duct and the relief duct of the pump piston by means of the position of the lower edge of the control slide. The end of the high pressure injection (seen from the time point of view as the end of spraying, on the one hand, and as the end of the high pressure delivery, determining the injection quantity, on the other) is

determined by the fact that the opening of the filling duct and relief duct on the pump piston is cleared by the control slide so that the fuel, which is under very high pressure, is relieved from the pump working space via the relief duct into the recess in the cylinder bush. The fuel jet which has been released has very high kinetic energy and this leads to a high load on the materials on which the jet impinges. In the known fuel injection pump of this type, there is a radial relief hole in the control slide and this relief hole is opened, after the effective injection stroke has been traversed, by an oblique control edge arranged as the control opening on the pump piston. When the relief hole is opened, the relief jet first impinges on the wall of the recess of the cylinder bush, where it is reflected and flows away from there with high kinetic energy into the return collecting duct, mentioned above, of the control slide adjustment shaft. Flowing away in this manner has the disadvantage that the deflected jet, which still has a very high kinetic energy, impinges on the wall of the suction space and flows at high speed past the edges into the return collecting duct. The jet thus acts on the pump housing, which is of a softer material than the pump cylinder bush and the control slide, which consist of hardened steel. The result is cavitation and erosion damage to the wall of the suction space of the pump housing and to the edges of the pump housing around which the flow occurs. These types of damage appear particularly at the transition between the recess and the transverse duct because, for design reasons, there is only a relatively small transition cross-section between the two; this transition is formed by the intersection of the two holes and forms sharp edges at this location.

#### Advantages of the invention

The fuel injection pump according to the invention with the characterising features of Claim 1 has, in

contrast, the advantage that while avoiding the disadvantages mentioned and retaining the pump dimensions, an increased cross-section is provided by means of which the fuel emerging at the pump piston can flow away between the recess and the control slide with the smallest possible hindrance, sharp-edged protruding housing wall parts susceptible to cavitation damage being avoided. An optimum overall cross-section configuration of the passage duct is possible by matching the shape of the control slide to the machined casing shape. In addition, there is a more favourable temperature distribution in the fuel injection pump due to the improved fuel removal because the fuel, which is greatly heated by the compression, can be removed better. Because of the machining of the housing from inside, it is possible to avoid a machining opening, the associated weakening of the cross-section and the complication of sealing. Further advantages and advantageous embodiments of the invention are apparent from the drawings and the description of the embodiment examples.

#### Drawing

An embodiment example of the subject-matter of the invention is shown in the drawing and is described in more detail below. Figure 1 shows a partial longitudinal section through a fuel injection pump according to the invention, with the control slide located in its upper position on the pump piston. Figure 2 shows the embodiment example in a manner analogous to Figure 1 with the control slide in its lower position. Figure 3 shows a cross-section through the part of the fuel injection pump according to the invention in Figure 2 and Figures 4 to 6 show diagrammatic sketches of the machining by means of a tool introduced into the element hole.

#### Description of the embodiment example

In a pump housing 1 (partially shown in Figure 1) of a fuel injection pump, a cylinder bush 2 is inserted

in a longitudinal hole 3 in which a pump piston 4 is reciprocated by a drive, which is not shown. In the cylinder bush 2, there is a recess formed in the shape of a blind opening and forming a partial suction space 11, arranged in such a way that it accommodates a control slide 5 axially displaceable on the pump piston 4 which penetrates the partial suction space 11. The axial actuation of the control slide 5 takes place by means of an adjustment shaft 7 arranged in a transverse duct 6, which is located in the pump housing 1 transversely to the axis of the longitudinal hole 3 and which intersects the longitudinal hole 3 in the region of the partial suction space 11, thus forming a passage opening 16. A lever 8, which can be clamped by means of a screw 9 and therefore have its rotational position adjusted, is arranged on the adjustment shaft 7, the other end of the lever 8 protruding through the passage opening 16 into a groove 10 of the control slide 5. On its end remote from the drive, the pump piston 4 forms a pump working space (not shown here) in the cylinder bush 2. In order to supply this pump working space with fuel, the pump piston 4 has an axial hole 17 which, starting from the pump working space, opens into a transverse hole 21 and connects the pump working space to the partial suction space 11. The fuel supply into the partial suction space 11 takes place by means of a supply duct 23 in the pump housing 1, a throttle insert 25 provided with a throttle hole 24 and located in the supply duct 23 and a connecting duct 26 branching off from said insert and opening into the partial suction space 11. Also arranged in the outer surface of the pump piston 4 are two oblique grooves which form two control edges 22 and, adjoining the latter, each have a recess 20. The oblique grooves are arranged as a pair of control openings diametrically opposite to one another on the pump piston 4 and are connected to one another by means of a transverse hole 27 which also opens into the axial hole 17. The position of the control edge 20 can therefore be altered by rotating

the pump piston 4, a control rod 19 rotating the pump piston 4 by means of a control sleeve, not shown in detail. The control openings, with the control edges 22 and the recesses 20 interact with two radial holes (acting as relief hole 18) in the control slide 5, the edges of these relief holes 18 acting as control edges and their openings onto the side walls of the partial suction space 11 being directed approximately parallel to the transverse duct 6. In a fuel injection pump of this type, a plurality of pump elements 2, 4 with control slides 5 are preferably arranged in line in the pump housing 1; the control slides 5 are then actuated by the common adjustment shaft 7 whose drive members, in the form of levers 8, correspond to the number of pump elements 2, 4. This adjustment shaft 7 is, as already mentioned, located in the transverse duct 6 in the pump housing 1 and is supported rotatably at both its housing-side ends. So that the lever 8 on the adjustment shaft 7 can engage in the groove 10 of the control slide 5, the passage opening 16 from the transverse duct 6 to the longitudinal hole 3 of the pump element 2, 4 is necessary in each cylinder bush 2. This passage opening 16 is also used to carry fuel from the partial suction space 11 into the transverse duct 6 which is also used as the return collecting duct. This passage opening 16 in known fuel injection pumps is embodied in such a way that a certain opening size arises from the intersection of the two holes 3, 6 due to the geometrical arrangement of the transverse duct 6 relative to the pump element axis and, for design reasons, this opening size cannot exceed certain limiting values. In order to permit a favourable fuel return, the passage opening 16 is therefore widened in trough shape. Thus, at the passage opening 16 to the transverse duct 6, the inside of the pump housing 1 has a housing chamfer 13 beginning at the boundary 15 of the partial suction space 11 on the pump working space end and reducing to the transverse duct 6, this chamfer 13 being formed by the removal of the edges on the pump

housing 1 which were hindering flow. As a supplement to this, the control slide 5 has a chamfer 12 on the end facing towards the pump working space and the transverse duct 6 and this chamfer 12 is located in the region of the plane of symmetry of the partial suction space 11 through the pump piston axis. This chamfer 12, whose slope is determined by manufacturing considerations, provides a large cross-section of the passage opening 16, which is favourable from the flow point of view, for small design size of the fuel injection pump and small axial extent of the partial suction space 11. By means of the design configuration described above, it is possible to carry out the machining of the pump housing 1 in a simple manner from the longitudinal hole 3 of the pump element 2, 4. Some machining possibilities are shown in Figures 4 to 6. The tool 40 in Figure 4, a cylindrical milling cutter with a size corresponding to the trough-shaped milling cut and with conical flanks 44, is axially introduced into the longitudinal hole 3 and is pushed, at the level of the transverse duct 6, radially against the edges of the housing 1 at the transverse duct 6. The tool 40 in Figure 5 is a shank-type milling cutter and is introduced tilted and offset relative to the pump element axis in order to produce the milling cut. Its conical tip 43 then forms the conical side walls. In the case of the tool 40 of Figure 6, only an axial feed of the tool 40 is again necessary for machining. In this case, the tool 40 is introduced into the longitudinal hole 3 and an adjustable conical cutting tool 41 is driven out from the main spindle 42 of the tool 40 at the level of the transverse duct 6. Figures 2 and 3 show the subject-matter of the invention in a manner analogous to the construction described in Figure 1, Figure 2 showing the control slide 5 in a lower position and Figure 3 showing a cross-section through Figure 2, in which two side chamfers 30 on the control slide 5 are arranged on the side facing the adjustment shaft 7 in the radial plane of the pump piston 4, the chamfers 30 narrowing the control

slide 5 in the direction of the adjustment shaft 7.

The embodiment example shown operates as follows. In the position of the pump piston 4 and the control slide 5 shown in Figure 1, the pump working space is filled with fuel by means of the transverse holes 21 (which are open to the partial suction space 11) and the axial hole 17 and by means of the recesses 20 of the control grooves which open into the transverse hole 27 protruding into the axial hole 17. During the delivery stroke of the pump piston 4, some of the fuel is first displaced, via the axial hole 17 and the transverse hole 21, from the pump working space back into the partial suction space 11 until the control edges 22, recesses 20 and transverse holes 21, 27 are covered by the control slide 5. From this delivery stroke position, the high pressure can develop in the pump working space and the injection to the internal combustion engine can begin. This injection is ended when the control edges 22 arrive at overlap with the relief hole 18 of the control slide 5. The fuel, which is under very high pressure, is now removed from the pump working space via the axial hole 17 and the relief hole 18 into the partial suction space 11 and there impinges on the wall of the latter with much kinetic energy. The enlargement of the cross-section of the passage opening 16 now acts in an advantageous manner because the fuel at high pressure and high temperature can now rapidly flow away into the transverse duct 6 via the increased cross-section without meeting flow hindrances. The result of this is a rapid lowering of the local temperature in the partial suction space 11, less cavitation effects on the non-hardened pump housing walls and, therefore, less material wear - thus contributing to a longer life for the whole of the fuel injection pump.



#### Claims

1. Fuel injection pump for internal combustion engines having, arranged in a hole (3) of a pump housing (1), a cylinder bush (2) in which a reciprocating pump piston (4) bounds a pump working space into which a filling and, relief duct (17, 20, 21) of the pump piston (4), which opens at the periphery of the pump piston, open in order to control the high pressure delivery of fuel and having a control slide (5) which can be axially adjusted on the pump piston (4) within a lateral, essentially cylindrical recess forming a partial suction space (11) in the cylinder bush (2), and which interacts with the filling and relief duct, which control slide (5) is moved by an adjustment shaft (7) by means of a lever (8) protruding through the side opening (16) into the cylinder bush (2) in the region of the partial suction space (11), the adjustment shaft (7) being arranged in a transverse duct in the pump housing (1) extending transversely to the hole (3) and intersecting the latter to form a passage opening (16), characterised in that the diameter of the transverse duct (6) is smaller than the axial extent of the partial suction space (11) and a trough-shaped cross-section transition is formed between the hole (3) and the transverse duct (6), a pump working space end chamfer (12) being provided on the control slide (5), the slope of which chamfer preferably corresponding to a shape of the cross-section transition of the passage opening (16) rising obliquely on the pump working space side to the hole (3).

2. Fuel injection pump according to Claim 1, characterised in that the control slide (5) is made narrower by means of lateral chamfers (30) in a radial plane of the pump piston (4) on the side facing towards

the adjustment shaft (7) (Figure 3).

3. Fuel injection pump according to Claim 1, characterised in that the cross-section transition at the passage opening (16) between the hole (3) and the transverse duct (6) is preferably manufactured by means of a cylindrical milling cutter with conical flanks (44), which is introduced into the pump housing (1) via the hole (3).

4. A fuel injection pump substantially as herein described with reference to the accompanying drawings.

**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

-10-

Application number

GB 9216924.2

**Relevant Technical fields**

(i) UK Cl (Edition K ) F1W (WDR, WGD)

(ii) Int Cl (Edition 5 ) F02M

**Databases (see over)**

(i) UK Patent Office

(ii)

**Search Examiner**

H F YOUNG

**Date of Search**

11 NOVEMBER 1992

Documents considered relevant following a search in respect of claims 1 TO 4

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

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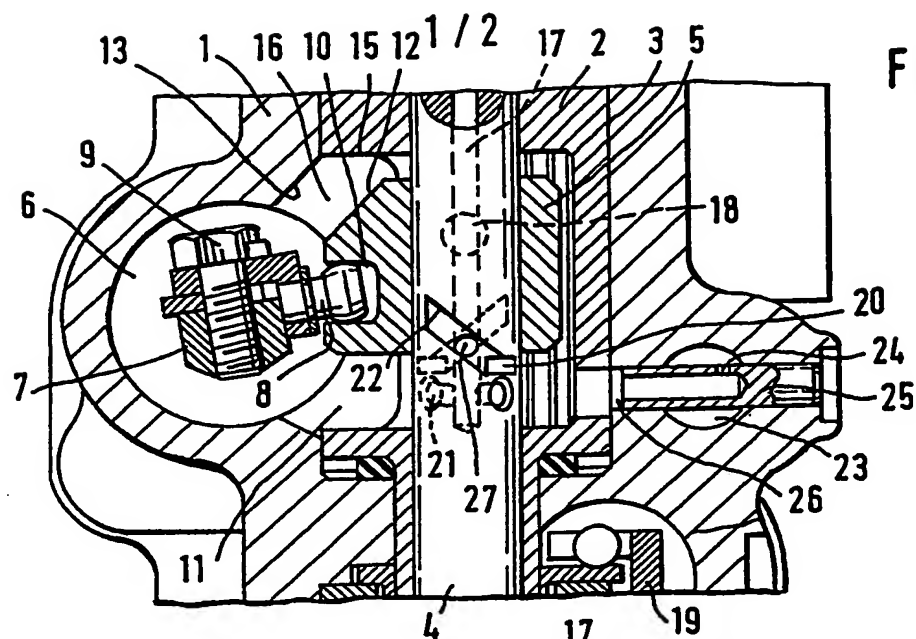


FIG. 1

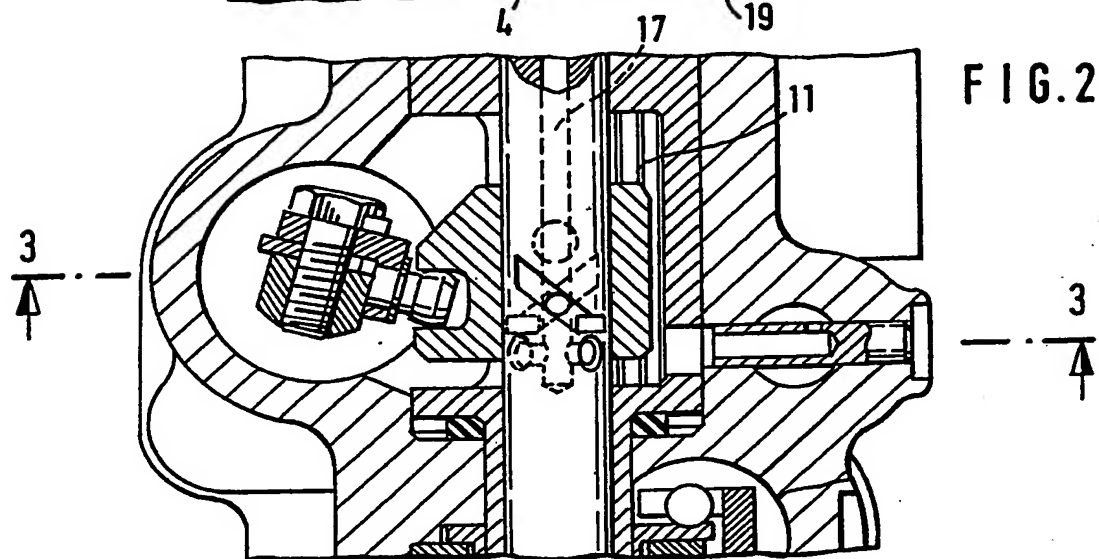


FIG. 2

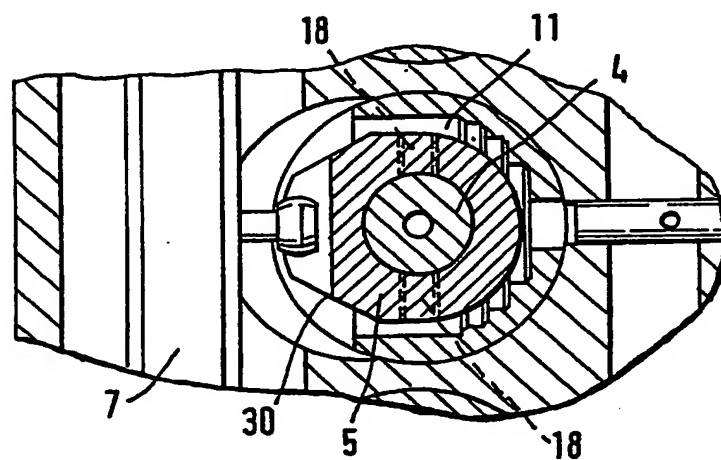
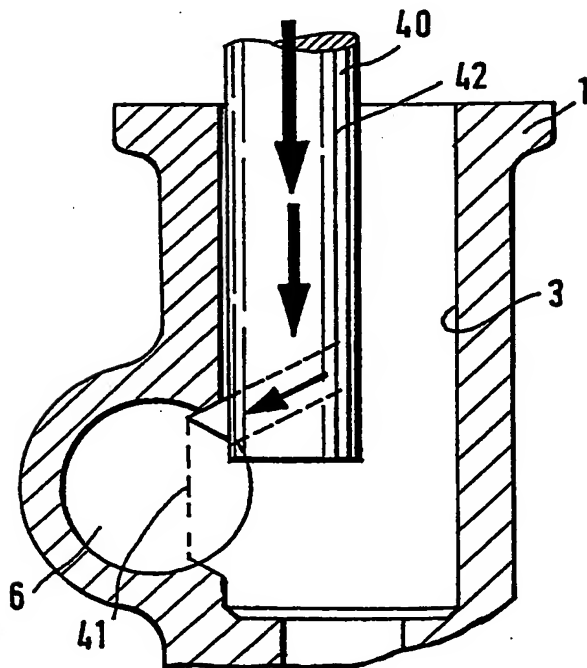
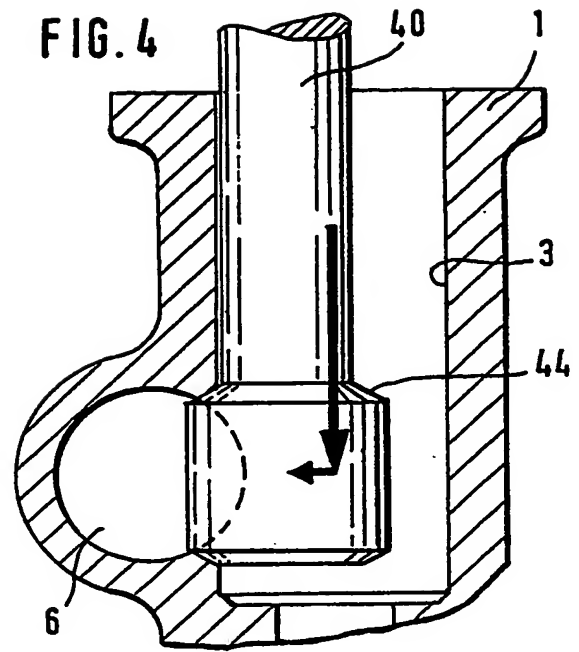
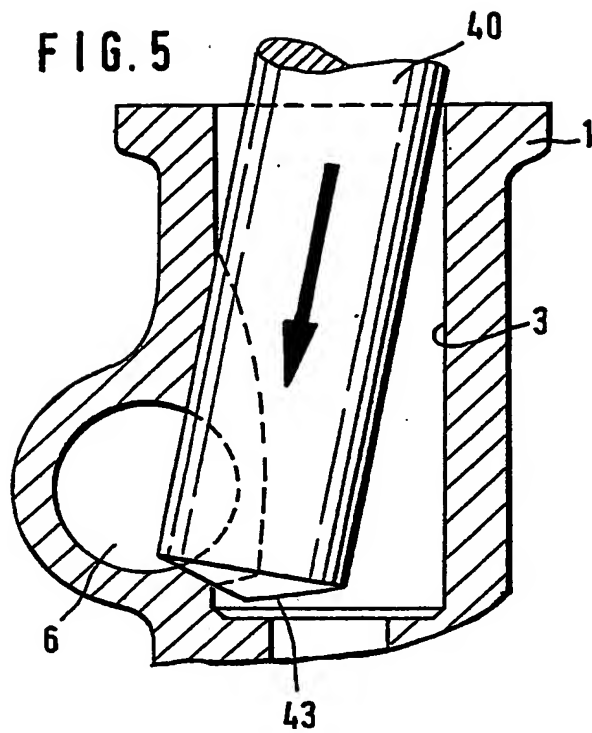


FIG. 3



**FIG. 6**

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